Feature Extraction Shape Kawi Numbers and Java Images Using The Zernike Moment

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H Nugroho[1], W Widodo[1], R K Hapsari[1] and L A Hermanto[1]
[1]Department of Informatic Engginering, Faculty of Information Technology, ITATS, Jl Arief Rachman Hakim 100, Surabaya, Indonesia

dosh3ndro@itats.ac.id[1)]

Abstract. The writing of Kawi and Javanese numeric characters has different forms, in order to find out the extraction value of the image form features of Kawi and Javanese numerals, the Moment Zernike method is free from rotation. To prove the Zernike Moment method feature extraction, a number of rare research processes are carried out, the steps are (1) image input, (2) grayscale, (2) threshold and region growing segmentation process, (3) extraction of the Zernike Moment feature. The results obtained from the test from the nearest value approach using city block extraction feature Kawi and Java numeric images with extraction features of rotated features 90^0 and 180^0. The results obtained are the same as 0.01 for the Kawi 1 and 0.02 numbers for Java number 2.

1. Introduction

The development of ancient Javanese script writing originated from Pallawa script which experienced the improvement of the form of letters around the VIII century [1]. Early Javanese script writing is aksara kawi (750-925) [1]. During the Nusasantara kingdom there were Ddinoyo inscriptions from Malang, Sangkhara Inscriptions from Sragen, and the Plumpung Inscription from Salatiga. The development of Javanese Kawi characters ended in the days of the Medang kingdom, the kingdom of Kediri (925-1250 AD), and developed the Majaphit script (1250-1450 AD) for example the Kudadu inscription from Mojokerto.

From the ancient Javanese writings in the period to experience many changes from writing kawi to Javanese writing now. In this study the writing of ancient Javanese characters taken as research material is ancient Javanese numeric characters. Ten-based numerical writing already exists in our ancestors in the Kedukan Bukit inscription by reciting the number "sarivu tluratus sepuluh dua " [2].

The ancient Javanese digit numbers are taken as image data of ten of the Kawi characters and Javanese characters. To find out the writing pattern of ancient Javanese numerals (Kawi and Java), the image of ancient Javanese characters was used and the form feature extraction process was carried out in the image. The use of form feature extraction to get number arrangements that can be used to identify [3].

The form feature extraction is included among fourier descriptors, invariant moments, and Zernike moments[3]. The use of Zernike Moment is used for image processing for the first time by M.R. Teague in 1980 [4] [3]. The advantage of Zernike Moment which results in the form of Zernike Moment Descriptors (ZMD) which has advantages that are independent of the rotation, is not affected by noise and has a minimum of information redundation [5].

The development of Javanese numeric characters began with Pallawa script which experienced simplification of form around the eighth century. The ancient Javanese script called the Kawi script is

a historical Brahmi script that was once used in Java and Bali. The kawi script in its development became the ancestor of traditional Javanese, Balinese, Sundanese characters, etc. [1]. In the period of development the Javanese script in writing was delivered in four parts, namely Javanese-Hindu script, Javanese-Islamic script, and Javanese-colonial script [6].

Javanese numeric script writing has the same number symbol as the Hindu-Arabic numerical system base, namely 0, 1, 2, 3, 4, 5, 6, 7, 8, and 9. For examples of writing the symbol of Jawa Kawi number can be seen in the picture 1. And for the symbols of Javanese numerals (Javanese-Hindu, Javanese-Islamic, and Javanese-Colonial) in Figure 2.

In Figure 1 and Figure 2 which will be input material for Javanese script pattern recognition research that is taken only one number to get an extracurricular pattern of form features from the Javanese numeric symbol.

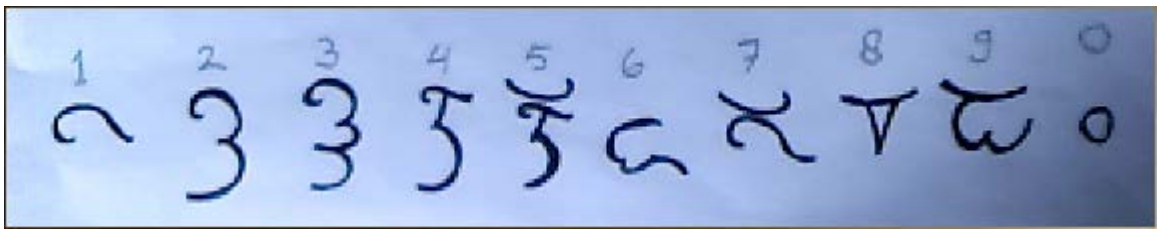


Figure 1. Kawi Number Script

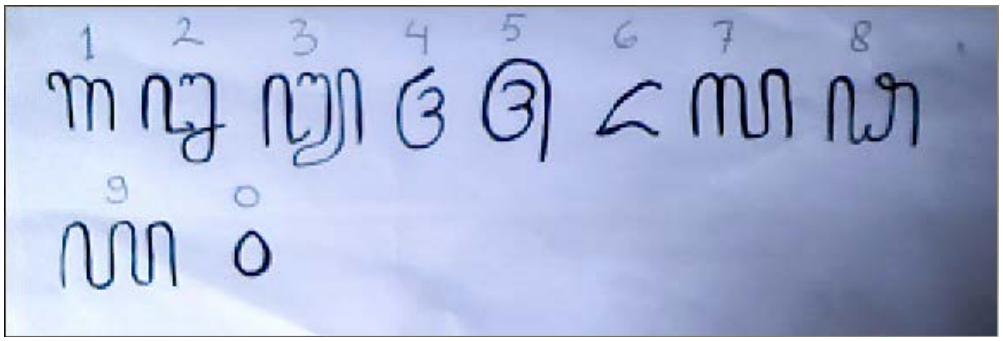


Figure 2. Jawa Number Script

2. Method

To get an introduction to the image pattern of ancient Javanese script writing, namely Kawi script and its developmental Javanese script (Figure 1 and Figure 2), the extraction feature of the Javanese script writing feature is needed. Before getting the Javanese numeral image feature extraction values the first step is segmentation of the Old Javanese numeral image image to get the binary value in the image and after that the form feature extraction process is performed. The segmentation used in this study is Region Growing and feature extraction used is the Zernike Moment.

2.1. Segements Region Growing

Image segmentation is a process that is shown to get objects contained in the image or divide the image into several areas with each object or area having similar attribute [3]. Separation between background and foreground images can use edge detector approaches or similarities between pixels in an area [7]. Based on segementation techniques can be divided into four categories, namely [8]. Threshold, edge-based, region-based, and hybrid methods.

The method used in this research is region-based because it only requires image segmentation in homogeneous regions of the Old Javanese numeric script written in black. The Growing Region method by starting several pixels (Seed) which represent different image regions and growing the region to fill the entire image.

For the Region Growing method, researchers have rules governing the mechanism for the growth of seeds and another rule that tests the homogeneity of the region after one stage of growth is complete.

The mechanism for growing seeds at each level and for each Region Ri(k), i=1,2,…,N and tested whether there are pixels that have not been classified in the 8-neighboring of each pixel on the edge of the region.

The allocation of a pixel x to the Region Ri (k), is tested whether the homogeneous region P P(Ri(k) ∪ {x}) = TRUE, is valid.

2.2. Metode Moment Zernike

Zernike's moment was introduced by F, Zernike (1934), the application of the Zernike moment for form feature extraction in the form of Zernike Moment Descriptors (ZMD). The Zernike moment is based on the Zernike polynomial that is orthogonal to the circle $x^2 + y^2 \leq 1$, which is stated as equation 1[3].

$$V_{pq}(x,y) = U_{pq}(r\,cos\theta, r\sin\theta) = R_{pq}(r).\exp(jq\theta) \quad (1)$$

With r is the radius of (x, y) the center of mass (centroid), θ is the range between r and x axis. $R_{pq}(r)$ is an orthogonal radial polynomial like equation 2

$$R_{pq}(r) = \sum_{s=0}^{(p-|q|)/2}(-1)^s \frac{(p-s)!}{s!\left(\frac{p+|q|}{2}-s\right)!\left(\frac{p-|q|}{2}-s\right)!}\rho^{p-2s} \quad (2)$$

In this case n = 0,1,2,…; $0 \leq |q| \leq n$, $j = \sqrt{-1}$, and p-|q| even value.
The Zernike moment codes p with the repetition of the continuous function f (x, y) as much as q is stated in equation 3.

$$Z_{pq} = \frac{p+1}{\pi}\int_y\int_x f(y,x).V^*_{pq}(y,x)\,dy\,dx;\; x^2+y^2 \leq 1 \quad (3)$$

In this case, V * denotes the conjugate, while Vpq (x, y) is named as the function of the Zernike base with p-order with repetition of q. This function is in equation 4.

$$V_{pq}(y,x) = V_{pq}(\rho,\theta) = R_{pq}(\rho).\exp(jq\theta) \quad (4)$$

With p in the form of zero or positive integers and n = p- | q | even and | q | ≤ p.
If the digital image input f (x, y) using equation 4 can be used with equation 5.

$$Z_{pq} = \frac{p+1}{\pi}\sum_y\sum_x f(y,x).V^*_{pq}(y,x) \quad (5)$$

If the image is rotated at an angle of α Zernike moment functions in the form of equation 6.

$$Z'_{pq} = Z_{pq}.e^{-jq\varphi} \quad (6)$$

Equation 6 states that if only the magnitude of the Zernike moment used will be obtained the feature does not depend on the rotation.

Low-order Zernike polynomials are useful for obtaining global features of a form, while high-order polynomials can capture local form or feature details [9].

3. Result

The workmanship process in this study to get an introduction to the writing patterns of Old Javanese numeric numerals can be seen in the diagram of the workmanship steps that can be seen in Figure 3. In the figure 3 there are several steps in the process, namely the input of ancient Javanese numerals in the form of Kawi numerals and Javanese numeric characters, the process of grayscale image to get gray values in the image that will be used by the segemnetation process, the segmentation process uses the Threshold method to get binary values (black and white) and Growing Region to get the region of the number object from the binary image and to eliminate noise, and the last is extracting form features using the Zernik moment method.

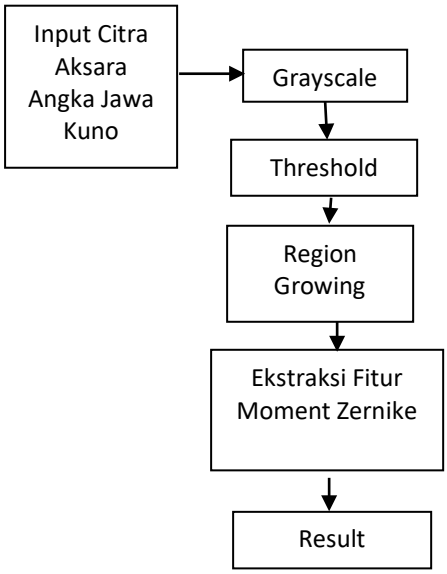


Figure 3. Introduction to Kawi and Javanese Literacy Patterns

The results obtained from the introduction of the Old Javanese Numerical Pattern pattern can be seen in figure 4. The results of the process begin the image input of one ancient Javanese numeric script, the grayscale process, the segmentation process of the Threshold, and Growing Region processes. The results of the Zernike Moment form extraction results in the form of tables resulting from Figures Kawi and Java as research material for Old Javanese writing patterns.

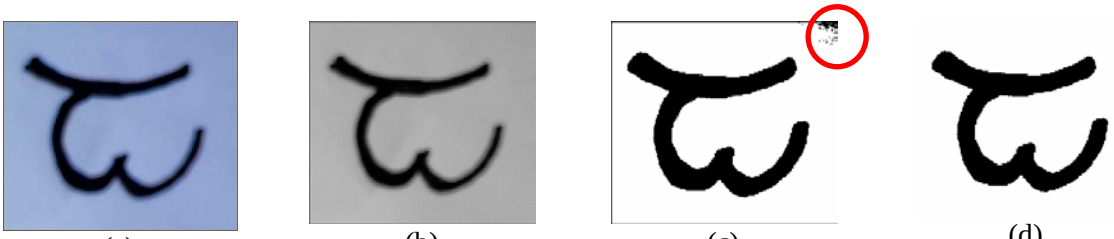


Figure 4. (a) Input image of Kawi Number 9, (b) Image of Grayscale, (c) Image of binary binary (black and white) there is noise (red circle), (d) Citra Region Growing

The results of the extraction of the form feature of the Moment Zenike method have seven moment values based on the equation 1 to 6. The extraction features of the Moment Zenike method image of the Java Kawi number are presented in table 1, and for the Java numeral images are presented in table 2.

In table 1 extraction of the Moment shape feature Zenike numbers Kawi has seven moment values for the kawi image starting from number 0 to number kawi 9. From the extraction value the Zernike Moment form feature for the numerical image pattern recognition research can be compared to the extraction feature shape the image of the Java number presented in table 2.

Table 1. Zernike Moment Form Extraction Result Result of Kawi

Nama Citra	Moment Zernike							
	Z1	Z2	Z3	Z4	Z5	Z5	Z6	Z7
Kawi 0	0,000654	0,267173	0,000291	0,009712	0,117361	0,00283	0,207766	0,000654
Kawi 1	0,113842	0,501926	0,003291	0,008793	0,001037	0,254577	0,105368	0,113842
Kawi 2	0,026417	0,356537	0,003176	0,018925	0,093412	0,016929	0,092113	0,026417
Kawi 3	0,035137	0,361862	0,003596	0,03092	0,087044	0,034078	0,112283	0,035137
Kawi 4	0,063775	0,423388	0,001728	0,018131	0,055437	0,092623	0,028562	0,063775
Kawi 5	0,066467	0,396512	0,006539	0,027184	0,056722	0,09393	0,101055	0,066467
Kawi 6	0,053727	0,359792	0,003433	0,039916	0,078998	0,078066	0,123954	0,053727
Kawi 7	0,082643	0,419454	0,006833	0,015119	0,040018	0,1497	0,069585	0,082643
Kawi 8	0,072239	0,367871	0,010446	0,034853	0,063072	0,130536	0,149305	0,072239
Kawi 9	0,037403	0,318909	0,007814	0,027234	0,096436	0,050406	0,160168	0,037403

Table 2 results of extras extras on the Zernike Moment form feature on the Java Numbers image are also presented in the form of a table consisting of ten Javanese numeric images from numbers 0 to 9, and have seven moment values from the Moment Zenike method.

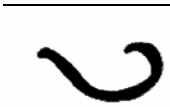
Table 2. Zernike Figures Java Moment Extraction Feature Features

Nama Citra	Moment Zernike							
	Z1	Z2	Z3	Z4	Z5	Z5	Z6	Z7
Jawa 0	0,024287	0,30313	0,001374	0,01975	0,10436	0,034309	0,190437	0,024287
Jawa 1	0,047861	0,360196	0,001293	0,037244	0,081885	0,007221	0,117963	0,047861
Jawa 2	0,036292	0,330865	0,003227	0,023391	0,097185	0,060691	0,125705	0,036292
Jawa 3	0,036497	0,330994	0,003341	0,023902	0,097208	0,061488	0,125056	0,036497
Jawa 4	0,038666	0,370691	0,002497	0,010592	0,088641	0,044132	0,088784	0,038666
Jawa 5	0,021895	0,319713	0,00489	0,036913	0,105536	0,021553	0,140585	0,021895
Jawa 6	0,010727	0,276985	0,005851	0,013508	0,11376	0,030554	0,168103	0,010727
Jawa 7	0,067674	0,400405	0,006638	0,02011	0,05912	0,100642	0,070168	0,067674
Jawa 8	0,047183	0,365176	0,002128	0,008097	0,081003	0,056895	0,098707	0,047183
Jawa 9	0,083648	0,449517	0,003811	0,015968	0,035971	0,154403	0,007435	0,083648

4. Discussion

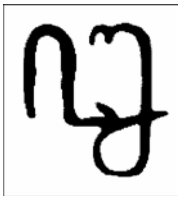
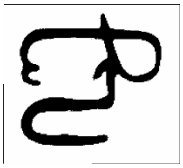
To find out the success rate of the Moment Zenike method in the Kawi and Javanese numeric scripts, tests were carried out on the image of 90^0 and 180^0 rotation of the Kawi and Javanese numerals. This image is played to test the Zernike Moment free of rotation. Tests on rotation images of Kawi numerals can be seen in table 3.

Table 3. Example of Zernike Moment Shape Extraction Feature The Kawi 1 number is rotated

Citra Kawi	Moment Zernike							
	Z1	Z2	Z3	Z4	Z5	Z5	Z6	Z7
	0,113842	0,501926	0,003291	0,008793	0,001037	0,254577	0,105368	0,113842
	0,112789	0,502538	0,004833	0,010295	0,000399	0,251874	0,10648	0,112789
	0,112902	0,502563	0,006256	0,008231	0,00022	0,25236	0,107374	0,112902

In table 4 also presents the results of extraction in Javanese numeric script with the same the rotation process as the Kawi numerals, 90^0 and 180^0.

Table 4. Example of Zernike Moment Feature Extraction Results of Java 2 Numbers that are Rotated

Citra Kawi	Moment Zernike							
	Z1	Z2	Z3	Z4	Z5	Z5	Z6	Z7
	0,036292	0,330865	0,003227	0,023391	0,097185	0,060691	0,125705	0,036292
	0,034375	0,32837	0,005542	0,022631	0,098528	0,05826	0,131549	0,034375
	0,033614	0,329293	0,006774	0,027526	0,097911	0,055311	0,127374	0,033614

To find out the Zernike Moment method is free from the rotation, it is tested by approaching the feature extraction value of the Kawi numerals and Javanese characters which have not been rotated with rotated Kawi numerals presented in Tables 3 and 4.

Approach to knowing the similarity of form feature extraction values using the closest distance to the City Block method. The results that are pegged at the nearest value in the Kawi 1 numeral can be seen in table 5.

Table 5. Distance Result Nearest Zernike Moment Shape Feature Extraction Image of Kawi 1

Citra Kawi	Nilai	
	Rotasi (derajat)	Jarak Terdekat dengan citra Angka Kawi 1 Tanpa di Rotasi
	90	0,01
	180	0,01

Table 6. Distance Result Nearest Zernike Moment Shape Feature Extraction Image of Java 2

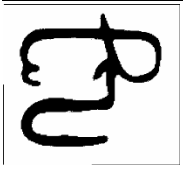
Citra Kawi	Nilai	
	Rotasi (derajat)	Jarak Terdekat dengan citra Angka Kawi 1 Tanpa di Rotasi
	90	0,02
	180	0,02

Table 5 and table 6 show the image of Kawi numerals and Javanese scripts which are manually rotated 90^0 and 180^0, calculated the proximity of Zernike Moment feature extraction value with the image that is not rotated has the same value of 0.01 (double digit) and 0 , 02 (rounded by two digits).).

5. Conculsion

The conclusion of the research extraction of the shape features using the Zernike Moment Method on the image of Kawi and Javanese numerals has different values in each Kawi numeral image and Javanese number. For images to be rotated by Kawi numerals and Java 900 and 1800 numbers manually as material for testing the Zernike Moment method free from the rotation shows the same value for the closest proximity using City Block method which is 0.01 for the image of Kawi 1 and 0 characters, 02 for Javanese numerals 2

6. References

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